Effect of Defects of GA Aircraft

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General aviation (GA) aircraft are generally manufactured using low cost materials and processes. Although a number of GA aircraft have been certified, some aspects of the performance of the materials and designs used are not well understood. This work investigates the impact of process-induced defects on durability for this type of low-cost composite aircraft structures. The objective of this work is to provide more effective tools for the ACO (air certification office) and the manufacturer to assess the safety implications of various scales of manufacturing defects.

The effort is divided into three phases of which the first is underway. In this presentation the findings from the first phase will be described and the theoretical basis of the second and third stages discussed. The defect under investigation is process-induced porosity, which can exist at various levels in the form of localized or distributed (global) defects.

The first stage of the project is to characterize the defects found in the manufacturing process. Other investigators have shown that the shape of defects is dependent on the manufacturing process and that it significantly affects the mechanical properties. As a result, it is essential to demonstrate that the porosity induced in test panels is equivalent to the porosity generated as a result of manufacturing process variations.
A series of monolithic and sandwich panels have been made. Two distinct methods were used to induce porosity and the panels were evaluated nondestructively using ultrasound. The test panels were then cut into coupons and tested mechanically. Optical microscopy specimens were prepared from the off cuts. Using simple image analysis techniques, characteristic statistics were calculated to allow for a quantitative comparison with samples taken from rejected parts containing typical process induced defects.

On completion of the analysis of the first stage, the size effect theories developed by Professor Zdenek Bazant will be used to define a test program for typical structural elements. To develop a size effect law, the anticipated failure mode will be defined (based on the results of the first phase). From this, it will be possible to define a set of geometrically similar specimens, which will allow the same local loading conditions on the defect at varying scales.

By analyzing the results of the scale experiments, we will be able to determine a characteristic length related to the failure mechanics of the structural element and this can then be used to determine the way in which local defects affect the overall strength of the aircraft.